Title:

Glide Path Enlargement of Mandibular Molar Canals using K-files, the ProGlider File, and G-Files: A Comparative Study of the Preparation Times

Authors:

Farzana Paleker, BChD, MSc* and Peet J van der Vyver, BChD, MSc*

*From the Department of Odontology, School of Dentistry, Faculty of Health Sciences, University of Pretoria, Pretoria, South Africa

Corresponding author: Farzana Paleker
Email: farzanapaleker@gmail.com

Prof Peet van der Vyver
E-mail address: peetv@iafrica.com

Postal address: Oral and Dental Hospital, 4th and 5th Level, 31 Bophelo Road, Prinshof Campus, Riviera, Pretoria, 0002, South Africa
Research facility: The South African National Centre for Radiography and Tomography, Radiation Science, South African Nuclear Energy Corporation (Necsa), Pretoria, South Africa

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Abstract

Introduction: The preparation of a glide path prior to the introduction of rotary nickel-titanium instruments is a standard adjunct to ensure more safety during root canal preparation. The aim of this study was to compare the mean preparation time of manual instrumentation with K-Files (Dentsply/Maillefer, Ballaigues, Switzerland), G-Files (Micro-Mega, Besançon Cedex, France), and ProGlider (Dentsply/Maillefer) to prepare a glide path in curved root canals. **Methods:** The mesial canals of 90 mandibular molars (with curvatures angles between 25° and 35°) were selected. The specimens were randomly divided into 3 groups with 30 canals each, and canal preparations were performed by an endodontist using #10-15-20 stainless steel manual K-files (group KF), #10 stainless steel manual K-file followed by #12-17 G-File instruments (group GF), and #10 stainless steel manual K-file followed by #16 ProGlider instrument (group PG). The total time it took to prepare the glide paths was recorded with an electronic stopwatch. New instruments were used for each canal. **Results:** Glide path enlargement with the PG group (27.9 ± 8.6) and GF group (41.9 ± 20.1) were shown to be statistically significantly faster than stainless steel KF group (74.9 ± 24.1) using ANOVA ($p<0.05$). There was no statistically significant difference observed between the mean preparation times of the PG and GF groups ($p<0.05$). **Conclusion:** Glide path preparation times with the rotary instrument groups were significantly faster than with stainless steel manual K-files.

Keywords: Glide path management, G-Files, ProGlider, Stainless steel K-Files, preparation time

Introduction

The creation of a glide path that is smooth and centered from the root canal orifice to the physiologic terminus facilitates shaping with rotary nickel titanium (NiTi) instrumentation because it allows for the tip of the rotary instrument to follow(1–4). A successful glide path can prevent taper lock, instrument fracture and shaping aberrations like ledge formation, perforation and transportation (5–7). Instruments used for initial canal negotiation should ideally be flexible and small to permit their progression in an apical direction with safety and efficiency (8,9). An initial brief manual instrumentation enables torsional stress to be drastically reduced because the canal width becomes at least equal to the diameter of the tip of the next instrument to be used (7). Once established, a successful glide path permits unrestricted access to the apical part of the canal and it also allows for an understanding and appreciation of the original anatomy (10). Ultimately, a glide path ensures that the root canal diameter is larger than or equal to the size of the tip of the first rotary instrument used (7) and must therefore be the starting point of all root canal preparations.

Various methods have been advocated for the establishment of a glide path. Initially, authors recommended the use of stainless-steel K-files by hand for glide path preparation to reduce the failure rate of nickel-titanium instruments (7,11–14). According to West, a glide path is present when a size 0.10 K-file fits loosely in the canal (15). Van der Vyver suggests that an established glide path is one where a size 0.15 K-file slides easily to working length without the need for rotation (16). However, the use of hand files may be difficult and time consuming particularly in teeth with constricted and/or severely curved root canals (17,18). Other authors advocate the use of a reciprocating hand piece in combination with stainless-steel K-files (19). This combination method reduces hand fatigue and cuts down considerably on clinical chair time, especially in cases with multiple narrow root canal systems (16,19,20). This technique is however associated with a higher risk of apical transportation with files larger than a 0.15 K-file (16); risk of excess dentine removal as a result of the clinician instrumenting the canal longer than necessary (21); risk of apical extrusion of debris if the handpiece is forced apically (20); and decreased tactile sensation.

The use of a small size stainless steel K-file for initial canal negotiation followed by more flexible and less tapered NiTi rotary glide path files have been established as a less invasive and safer method for glide path enlargement. This technique reportedly respects the original canal anatomy in comparison with manual glide path enlargement exclusively performed with stainless steel K-files (22). Rotary NiTi instruments include PathFiles (Dentsply/Maillefer, Ballaigues, Switzerland), G-Files (Micro-Mega, Micro-Mega, Besançon Cedex, France), EndoWave Mechanical Glide Path Kit (J Morita, California, USA), Scout-RaCe Files (FKG Dentaire SA, La Chaux-de Fonds, Switzerland), Race ISO 10 (FKG Dentaire SA) and X-Plorer Canal Navigation NiTi Files (Clinician's Choice Dental Products Inc., Milford USA) and ProGlider (Dentsply/Maillefer).

G-Files are NiTi glide path enlargement instruments introduced in 2011 that consist of two files, G1 (#0.12 mm) and G2 (#0.17 mm). Both instruments have a constant 0.03 taper. The tips are non-cutting tip and asymmetrical to aid in the progression of the file. The files have a 3% taper along the length and an evolving cross-section that varies along the instrument. The cross-section has blades on three different radii to aid in the removal of debris and to reduce torsion. The files have an electro-polished surface to improve efficiency.

The ProGlider (PG), a single-file rotary instrument, is manufactured using Memory nickel-titanium wire (M-wire) technology making it almost 400% more resistant to cyclic fatigue (23). The M-wire alloy may also decrease the potential for file fracture and increase the flexibility of the instrument. The PG instrument has a square cross-section and a tip diameter of 0.16 mm at D0 and 0.82 mm at D16 and demonstrates a progressive taper from 2% to 8% over the cutting flute length. Manufacturers claim that it allows for a smoother glide path transition by making use of a controlled, smooth, inward-cutting action.

To our knowledge, no study has yet compared the differences in glide path preparation time using stainless steel manual K-files compared to G-Files (NiTi) and the ProGlider instrument (M-Wire) in curved mesial root canals of extracted mandibular molar teeth.

Materials and Methods

Specimen Preparation

Permanent, human, mandibular molars with curved mesial roots extracted for periodontal reasons were stored in with distilled water at 4°C until use. Digital x-rays using the RVG 6000 System (Eastman Kodak, Anaheim, USA) were taken to determine which teeth met the selection criteria Teeth were first exposed in a bucco-lingual view to determine which samples had separate mesio-lingual (ML) and mesio-buccal (MB) canals. A second x-ray was taken in a mesio-distal view to ascertain which canals had curvatures of 25° to 35° using Schneider's technique (24).) Sixty mandibular molars with previously untreated intact mesial roots with closed apices and separate canals with curvatures of 25° to 35° were ultimately chosen for this study. The selected teeth were scanned using the XTH 225 ST micro-focus X-ray computed tomography system (Nikon Metrology, Leuven, Belgium). VGStudioMax visualisation software (Volume Graphics GmbH, Heidelberg, Germany) was used to confirm the presence of separate mesial canals and recheck the canal curvatures of the MB and ML canals in coronal and sagittal slices respectively.

Standard endodontic access cavities were prepared and working length for each canal was determined. The selected curved canals were explored with a pre-curved #10 K-file (Dentsply/Maillefer). The working length of each root canal was determined by advancing this file passively into the root canal until the tip of the file was just visible at the apical foramen. This was done using the Heine® HR 2.5x High Resolution Binocular Loupes with LED (HEINE Optotechnik, Herrsching, Germany). Working length was determined by subtracting 0.5 mm from this measurement. To avoid any bias caused by in the initial canal width, any root canals that could be negotiated without any resistance up to the apex with a #15 K-File (or larger) were not included in the study. Accordingly, 90 root canals were selected and working length determined. The molars were randomly assigned to three experimental groups of 30 canals each for glide path enlargement.

Glide Path Preparation

Group KF: Glide Path Enlargement using Pre-Curved Stainless Steel K-files

Manual pre-flaring with pre-curved stainless steel K-files (Dentsply/Maillefer) in the following sequence: ISO #10, #15 and then #20 to working length (n=30). Glyde Root Canal Conditioner (Dentsply/Maillefer was used as a chelator in all canal preparations and 3% sodium hypochlorite (Jik, Rekitt Benckiser, South Africa (Pty) Ltd., Elandsfontein, Gauteng, South Africa) was used for canal irrigation after the use of each file.

Group GF: Glide Path Enlargement using the G-File system

A reproducible glide path was manually established with a pre-curved #10 stainless steel K-file before the glide paths were enlarged using G1 and G2 files (n=30). Glyde Root Canal Conditioner was used as a chelator in all canal preparations and 3% sodium hypochlorite was used for canal irrigation after the use of each file.

Group PG: Glide Path Enlargement using the ProGlider file

A reproducible glide path was manually established with a pre-curved #10 stainless steel K-file before the glide paths were enlarged using the ProGlider file (n=30). Glyde Root Canal Conditioner was used as a chelator in all canal preparations and 3% sodium hypochlorite was used for canal irrigation after the use of each file.

The time taken to enlarge this glide path in each canal, up to full working length, was recorded by means of an iPhone stopwatch (Apple Inc., Cupertino, California) by an assistant to the operator. The time taken to change files was not recorded. New instruments were used for each tooth. The stopwatch was started at the point of entry into the canal and stopped at the point of instrument retrieval. The time it took to clean debris from the instrument flutes, irrigate, recapitulate and to re-irrigate the canal was not recorded. In the groups where rotary systems were used (groups GF and PG) the preparations were performed with 4 in-and-out, backstroke brushing motions for each instrument, using an electrical motor (Endo Mate DT, NSK Europe GmbH, Eschborn, Germany) fitted with a 16:1 reduction contra-angle hand piece. The speed and torque levels as suggested by the manufacturers for each instrument were followed.

Statistical Analysis

Mean and standard deviations were determined for each group and ANOVA was used to statistically compare the mean glide path enlargement times for the three groups. Statistical procedures were performed on SAS Release 9.3 (SAS Institute Inc., Cary, USA) running under Microsoft Windows (Microsoft Corp., Redmond, Washington) for a personal computer.

Results

No specimens were lost as a result of instrument fracture or root canal blockage. The mean total time for glide path preparation and standard deviation values for the preparation groups are presented in Table 1. Glide path enlargement with the PG group and GF group were shown to be statistically significantly faster than stainless steel KF group using ANOVA ($p<0.05$). There was no statistically significant difference observed between the mean preparation times of the PG and GF groups ($p<0.05$).

Table 1. Descriptive statistics for the total preparation time (in sec) for the different groups

Technique	Number	Mean	Standard deviation	Minimum	Maximum
K-file	30	74.9^{a}	24.1	18.5	124.8
G-File	30	41.9^{b}	20.1	15.3	105.1
ProGlider	30	27.9^{b}	8.6	13.2	44.8

Mean values with the same superscript letters were not statistically different at $p<0.05$.

Discussion

This is the first study on curved root canals of extracted human molars to compare the time taken to prepare and enlarge the glide paths with pre-curved stainless steel K-files, G-Files and the ProGlider instrument. Curved root canals were selected for this study because they pose a clinical challenge for glide path preparation (18,25). A recent study on glide path management compared single (ProGlider) and multiple instruments (PathFiles) in curved mandibular canals (18). Results of this study showed that the ProGlider instrument prepared a glide path faster than PathFiles. A study by Van der Vyver et al. (2015) compared glide path enlargement times of the ProGlider file, PathFiles, X-Plorer Canal Navigation NiTi Files (Clinician's Choice Dental Products Inc.) and stainless steel K-files (26). They found that the enlargement time of the ProGlider file was significantly faster than all the other groups. The results of these studies can be explained by the fact that ProGlider is only one single instrument in comparison to the PathFile and the X-Plorer Canal Navigation NiTi File systems that consists of three files. A study by D'Amario et al. compared glide path enlargement times of G-Files, PathFiles (Dentsply/Maillefer) and stainless steel K-files. In their study, they found that the two-file G-File system prepared a glide path more rapidly than the other two groups that made use of three instruments. (17).

It is important to consider the final apical preparation size and the taper of canals prepared using the different glide path instruments. Several authors recommend creating a glide path to the same size, or ideally a size bigger than, the first rotary instrument introduced for root canal preparation (5–7). The final apical preparation sizes of the KF group were approximately ISO 0.2mm, followed by ISO 0.17 and ISO 0.16 for GF and the PG groups, respectively. Canals in the KF group will result in an average canal taper of 2% compared to an average of 3% for GF group. The PG instrument entered the canal to its full length of 16mm (cutting flutes) and it can be expected that it left the canals with a progressive taper ranging from of 2% at the apex to 8% at the canal orifice. Although the GF and PG showed the fastest mean glide path preparation time, it also resulted in the smaller apical preparation diameters. Although these parameters were not evaluated in this study, it could have an impact on further canal preparation with different sizes of rotary nickel-titanium preparation instruments. Further advantages of using stainless steel K-files compared with rotary NiTi files for enlarging the glide path include improved tactile sensation; decreased risk of file fracture (13); and decreased cost. Stainless steel K-files also provide an appreciation of curvatures in the anatomy when a file that is removed from a canal maintains the canal shape (7,16,27). The stiffness of stainless steel K-files allow for negotiation of canal blockages and calcifications (13,28); and there is no need for a dedicated hand piece (29).

Studies have however shown that glide path enlargement with NiTi files cause less procedural errors than stainless steel K-files used manually (22,30–32). A previously published part of this study examining canal centering and apical canal transportation showed that glide path enlargement with stainless steel K-files was less centered than the NiTi rotary glide path file groups at levels 1 mm from the apical foramen, at the point of maximum root curvature and 7 mm from the apical foramen (32). These are areas within the canal that are particularly vulnerable to iatrogenic mishaps (33,34). This study also demonstrated statistically significant differences in apical canal transportation between KF and the PG and GF groups. Stainless steel K-files were found to transport the canal significantly more than both NiTi rotary glide path file groups

In the present study, glide path enlargement time was fastest in the PG group. There was however no statistically significant difference observed between the mean preparation times of the PG and GF groups. It is important to note that the NiTi rotary file systems in this study were used only after initial instrumentation with a size #10 stainless steel K-file. The time it took for this initial instrumentation was also recorded and included in the total preparation times for the NiTi rotary file groups. Taking this into account, the PG and GF still enlarged the glide paths significantly faster than the KF group. The NiTi groups also displayed superior centering ability and transported fewer apices as discussed in a previously published part of this study (32). These qualities in addition to a faster preparation time make PG and GF potentially more suitable for curved canals in the clinical situation.
In conclusion, within the limits of this study, glide path preparation with GF and PG were shown to be statistically significantly faster than stainless steel KF. There was no statistically significant difference between the mean preparation times of GF and PG.

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